THE PROGRESS OF THE TELEGRAPH *

IX.

In all submarine cables the copper conductor is composed of seven small wires stranded together, an arrangement which gives much greater flexibility and strength than if a solid wire were employed. The general arrangement of the signal apparatus in connection with the cable is shown at Fig. 38. A, the battery, consists of a series of cells of Daniell's arrangement; B, the contact keys for passing the positive and negative currents into the cable; C, "switch," placing the cable in connection either with the earth, instrument, or battery as required; D, a form of Sir William Thomson's reflecting galvanometer placed in connection with the cable by switch C; E, the permanent magnet arrangement for steadying and adjusting the coil-mirror (shown in section and detail, Fig. 39); I, resistance coils interposed into the circuit

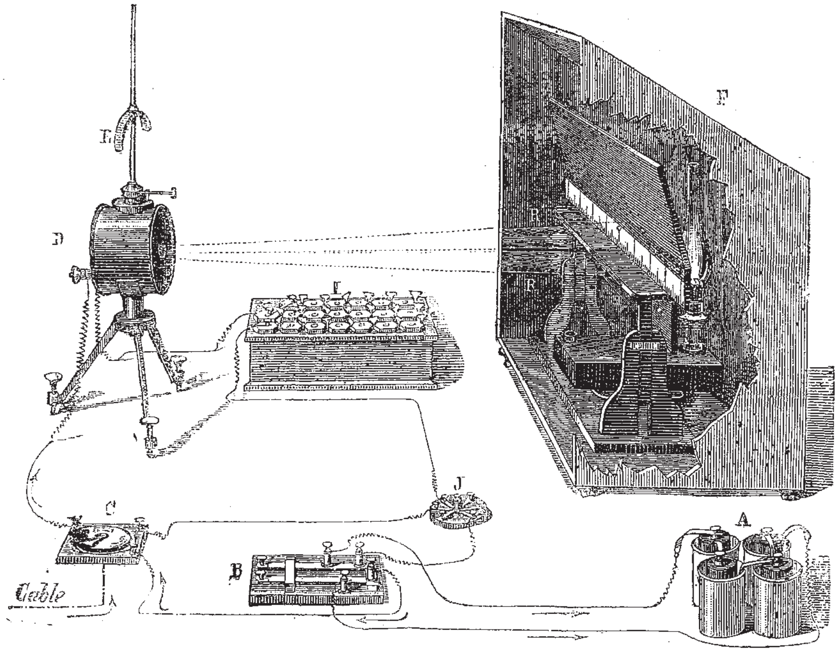

FIG. 38.—Genera arrangement of apparatus for working a submarine circuit.

between the instrument and the earth; J, a switch for connecting the line to earth; F, a darkened recess to receive the scale upon which the spot of light reflected from the lamp situated behind the partition, the ray from which, passing through a slit in the direction R is reflected back from the galvanometer mirror in the direction R′; the spot of light moves to the right or left of the zero on the scale, according as a positive or negative current is passed through the circuit; the several signals being indicated by the successive oscillations of the luminous image, signals which correspond to the conventional alphabet of the Morse system. The Morse alphabet is given at Fig. 40.

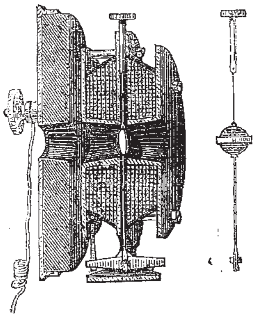

FIG 39.—Section of coil of Thomson's mirror galvanometer, showing the mirror and magnetic needle suspension.

A steam-engine without the motive power, steam, is nothing but an arrangement of iron levers, cranks, and throttle valves, useless so far as actual work is concerned. In like manner a telegraph instrument without the electric current to actuate its parts and give vitality to the circuit is valueless—a piece of apparatus to be inspected on a museum shelf. A few remarks upon "Batteries" are therefore necessary before an examination is made into the chief laws which regulate the passage of electric currents through metallic conductors.

In the production of a galvanic, or voltaic current, two conditions are essential, either the presence of two metals and a liquid, or two liquids and a metal. This will be explained by reference to everyday phenomena.

a	· —	o	— — —
ä	· — · —	ö	— — — ·
b	— · · ·	p	· — — ·
c	— · — ·	q	— — · —
d	— · ·	r	· — ·
e	·	s	· · ·
é	· · — · ·	t	—
f	· · — ·	u	· · —
g	— — ·	ü	· · — —
h	· · · ·	v	· · · —
i	· ·	w	· — —
j	· — — —	x	— · · —
k	— · —	y	— · — —
l	· — · ·	z	— — · ·
m	— —	ch	— — — —
n	— ·		

FIG. 40.—The Morse Alphabetical Code.

A familiar example of the development of an electric current by two metals and a liquid is continually presented to our notice in the wasting of the iron bars of a railing close to their junction with the stone coping. Here we have the two metals, the iron composing the

* Continued from p. 151.

railing, and the lead by which the iron is fastened into the stone, and rain or atmospheric moisture, as the liquid or exciting medium. The wasting away of the iron just above the coping stone is the result of the galvanic action set up between the two metals (iron and lead) and the liquid (the moisture of the atmosphere). To preserve an iron railing therefore it becomes necessary to dispense with the presence of lead; nothing can be better than the adoption of an iron coping in place of stone. As knowledge spreads, so practical results follow, and many modern examples of iron railings will be found to fulfil the conditions above indicated as necessary to ensure a "long life."

All connoisseurs of malt and hop beverages agree that ale drinks much sharper and is more tasty to the palate out of a pewter tankard than out of a glass. At a refreshment

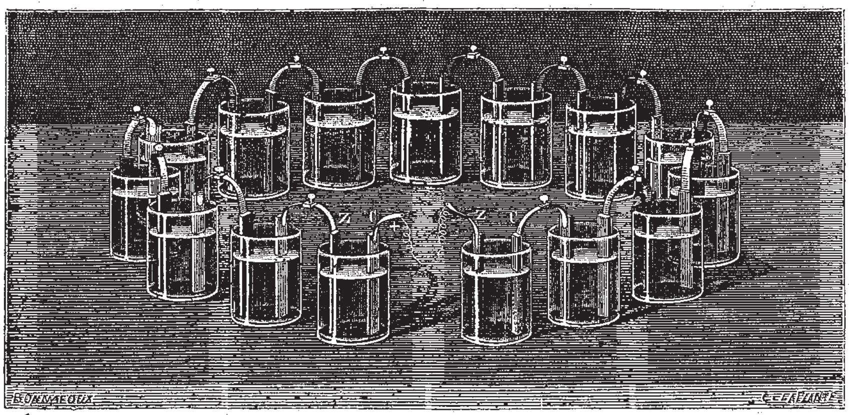

Fig. 41.—Voltaic Battery connected in series, in illustration of the *internal resistance* of the battery.

bar the demand is more often for "half a pint of bitter" (served in a metal vessel) than for a "glass of bitter;" and common belief in this instance is correct. Here we have a galvanic current set up by two liquids and one metal; the effect of the electric current so generated being to sharpen and improve the taste of the beverage to the palate by reason of electric action. In this example there are the two liquids—the beverage, and the saliva of the mouth—and one metal—that of the tankard—the resultant effect on the palate of the consumer being an increased *motive force* of the battery and upon the *resistance* of the circuit. The precise meaning to be attached to these terms was first pointed out by Ohm in 1827, who showed that the strength of the current is directly proportional to the former and inversely proportional to the latter. The statement of this relation is commonly spoken of as "Ohm's Law." The total resistance of a telegraphic circuit is made up partly of the resistance of the *battery*, and its necessary connections, and partly of the resistance of the metallic conductor constituting the *line*. Conse-

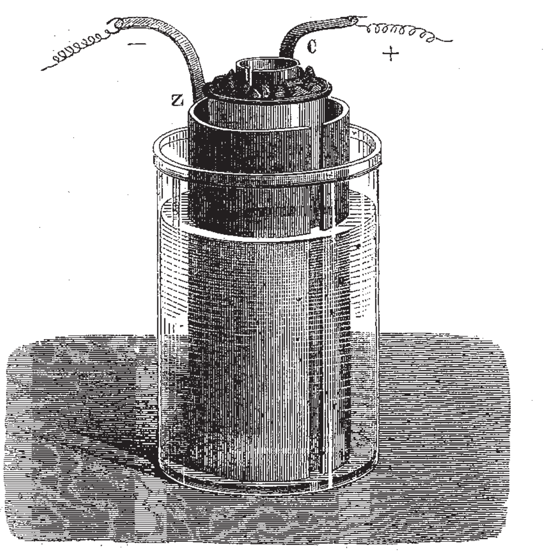

Fig. 42.—The Daniell Battery.

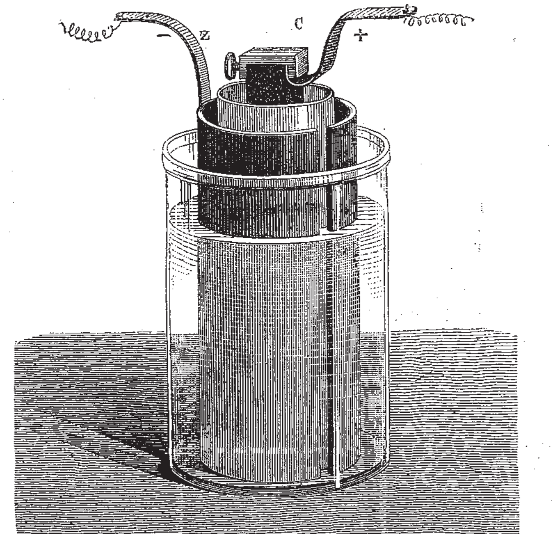

Fig. 43.—The Bunsen Battery.

life or vigour in the taste of the beverage. Thus, even in the trivialities of everyday life, electricity has a part to play. The generation of the voltaic current for telegraphic purposes is based upon one or other of these principles; and it is essential in telegraphy that the power of the current derived from the battery should be adjusted to the circuit.

The strength of the current depends on the *electro-*quently the law established by Ohm may be expressed as follows:—

The available effective force of any current = the electromotive force of the Battery—(the resistance of the Battery + the resistance of the line wire).

It has been found that in any given case the electromotive force and resistance depend upon conditions that may be thus stated:—

First, "*The electromotive force* of a voltaic circuit varies with the number of the elements, and the nature of the metals and liquids which constitute each element, but is in no degree dependent on the dimensions of any of their parts." Second, "*The resistance* of each element is directly proportional to the distances of the plates from each other in the liquid, and to the specific resistance of the liquid; and is also inversely proportional to the surface of the plates in contact with the liquids." Third, "*The resistance of the connecting wire of the circuit* is directly proportional to its length and to its specific resistance, and inversely proportional to its section." Some of the more important forms of battery in use will now be described.

Daniell's Battery, Fig. 42, consists of an earthenware or glass vessel, within which a smaller jar of some porous material is placed; the space between the inner and outer jars is filled with a dilute solution of sulphuric acid and water, and within the porous jar a saturated solution of sulphate of copper; a cylinder of zinc is immersed in the acid solution, and a cylinder of copper in the sulphate solution, crystals of sulphate of copper being introduced to maintain the strength of the copper medium. The current from this battery is remarkably constant, a matter of the greatest importance in the working of a telegraphic circuit, as with a variation in the working strength of the current, continued adjustment of the transmitting and recording apparatus is rendered necessary. Bunsen's battery (Fig. 43) in many respects resembles the Daniell arrangement; carbon is used within the porous cell in place of the copper cylinder, and nitric acid replaces the saturated solution of sulphate of copper. The current produced is stronger, but less constant than that from the Daniell's cell.

Many other arrangements for the generation of a voltaic current for telegraphic purposes are in use, such as the "Marié Davy" (Fig. 44), the "Leclanché," and "Callaud" batteries; more or less, each has its special merits and demerits: practically, the "Daniell" remains unsurpassed. The essential condition of every practical form of battery is that it shall produce a constant current be free from local action, and possess mechanical facility of renovation, with simplicity and economy of construction.

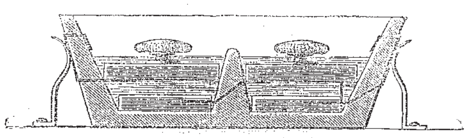

FIG. 44.—The Marié Davy sulphate of mercury Battery.

The measurement of the value of every telegraphic line as regards electrical resistance, as compared with some ascertained standard of resistance, is a matter of vast importance. By this means the electrical insulation of a submarine cable or a land wire is definitely ascertained, and the existence of a fault, together with its locality, defined. Without some established *unit* of resistance by which to compare the working circuit with its electrical equivalent, no test of insulation can be maintained or restoration of a circuit carried out. By general acceptance a standard of measurement has been adopted, a unit of resistance known as the B.A. (British Association) unit. It is unnecessary to enter into detail as to the mechanical problems which determine this unit of resistance; it is sufficient to state that the electrical resistance or value of every circuit, land wire and submarine cable, is now by universal acceptance recorded in B.A. units. For instance, a guttapercha submarine cable core may be stated to be so many hundred millions B.A. units of insulation test; while, again, an indiarubber core may be stated to be so many thousand millions of B.A. units of resistance; a correct comparison is thus at once determined.

(*To be continued.*)

OUR ASTRONOMICAL COLUMN

THE TRANSIT OF VENUS, 1882 DECEMBER 6.—The Greenwich time of first *internal* contact in this transit at any point in these islands, according to Leverrier's Tables of Sun and Planet, may be accurately found by the following equation, in which l is the geocentric latitude of the place, ρ the corresponding radius of the earth, and L the longitude, reckoned positive, if east of Greenwich, and negative, if west:—

$$\text{G.M.T. first Int. Cont.} = \text{Dec. 6d. 2h. 16m. 16s.}$$
$$+ [2{\cdot}5855]\ \rho \sin l - [2{\cdot}4774]\ \rho \cos l \cos (\text{L} - 85^\circ\ 58'{\cdot}6)$$

The quantities within square brackets are logarithms; the correction of course results in seconds. Direct computations for Greenwich, Edinburgh, and Dublin, furnish the following particulars of the first internal contact at these places:—

	Local Time. d. h. m. s.	Angle from N. point. ° ′	Angle from Vertex. ° ′	Sun's Altitude. °
Greenwich ...	Dec. 6 2 21 2 ...	150 40 ...	128 2 ...	9·2
Edinburgh ...	„ 2 8 46 ...	150 42 ...	132 8 ...	6·5
Dublin ...	„ 1 56 8 ...	150 41 ...	132 24 ...	9·6

At Greenwich the sun sets just one hour and a half after Venus has wholly entered upon the sun's disc.

THE SUN'S PARALLAX.—M. Liais, Director of the Imperial Observatory of Rio de Janeiro, has intimated his intention to make a serious attempt to determine this important element from the very favourable opposition of the planet Mars, which will occur early in September 1877, being encouraged thereto by the success which attended his observations about the opposition of 1860, when his instrumental appliances were very inferior to what they are likely to be in 1877. The planet arrives at perihelion on the 21st of August in that year, and in opposition at midnight on the 5th of September; it is in perigee on September 2nd at a distance of only 0·3767, which is not far from the minimum, though slightly greater than in the last three repetitions of the 79-year period, as will appear from the following comparison:—

Opposition.	Mars—Mean Anomaly.
1640·64	− 0° 12′
1719·65	+ 2 31
1798·66	+ 5 15
1877·68	+ 7 58

The horizontal parallax of Mars will attain a value which, as M. Liais remarks, will be sensibly equal to that of Venus, diminished by that of the sun. With firm instruments and experienced observers, it is very probable that the amount of solar parallax may be determined by differential observations of Mars at the opposition of 1877, with a precision which may be comparable with that resulting from observations of a single transit of Venus.

A THIRD COMET IN 1813 (?).—Bode, after mentioning in his Miscellaneous Notices (*Berl. Jahrb.* 1818) that Canon Stark of Augsburg had observed the first comet of 1813 on the 19th of February, states that Stark had also discovered on the same evening with a $3\frac{1}{2}$ feet Dollond telescope, a very small and exceedingly faint comet without tail above the variable star Mira in Cetus, the position of which, by comparison with the variable, he found to be at 7h. 28m. 37s., in R.A. 31° 17′ 23″, and Decl. 1° 52′ 9″ S. He saw the comet a second time on the 20th, and again comparing it with Mira, and another adjacent star, its place at 7h. 32m. 13s. was in R.A. 33° 47′ 3″, and Decl. 5° 49′ 7″ S. Cloudy skies are said to have prevented further observation. Bode remarks, with respect to this comet, that it is strange that no other astronomer had perceived it, "doch versichert Herr Stark," he adds, "noch in seinem letzten Schreiben an mich, aufs Heiligste, die Richtigkeit dieser Wahrnehmung." However suspicious this circumstance may have appeared, we know that several of the comets of short period have been revolving in such orbits for one or two centuries, visiting these parts of space without doubt under favourable